Amphibious Vehicle Suspension

The present invention relates to an amphibious vehicle having retractable road wheels each having a wheel suspension.

Such a vehicle is shown in US 5,531,179 (Roycroft et al). In order to improve the marine and road performance, it has been proposed to move the engine slightly forward; and to align the engine transversely as shown diagrammatically in Figure 3 of PCT/GB 01/03493 (Pub. No. WO 02/14092). Such a conformation however results in spatial problems, in that the outer ends of the engine block are very close to the suspension mountings.

An amphibious vehicle according to the invention has a body, retractable road wheels mounted to the body and arranged to be moved from a lower road engaging position in a land mode to an upper faired position in a marine mode, at least one of the road wheels having a wheel suspension, the suspension comprising a suspension member having a bearing for supporting the wheel, the suspension member being connected to the body by at least one upper link and one lower link, the bearing being ahead of any connection of the or each lower link with the vehicle body.

A McPherson type suspension strut could act as an upper said link, because it locates the suspension member carrying the wheel bearing.

Preferably, the bearing is also ahead of any connection of the or each lower link with the suspension member.

In this context, the term "ahead of" means "forward of"; so that the distance from the bearing to the forward, or bow, end of the body, is less than the distance from the lower link connection to said bow. Equally, the distance from the bearing to the rearward, or stern, end of the body, is greater than the distance from the lower link connection to said stern.

The wheel may have an asymmetric rim profile, as opposed to a symmetrical motorcycle wheel; in which case, the upper link(s) and lower link(s) support said wheel only on that side of the wheel which faces the vehicle.

The upper link(s) and lower link(s) may extend substantially transversely across the vehicle; again, in opposition to a motorcycle leading or trailing link suspension, where such links would extend substantially along the vehicle.

The suspended road wheel may longitudinally overlap at least one of the connections of a lower link to the vehicle body; and if driven, may also longitudinally overlap the vehicle engine.

At least two of the road wheels may each have a wheel suspension, each suspension comprising a suspension member having a bearing for supporting the wheel, the suspension member being connected to the body by at least one upper link and one lower link, the bearing being ahead of any connection of the or each lower link with the vehicle body.

Preferably, the driven wheel(s) driven by a drive shaft or shafts have their shaft bearing(s) ahead of the lower link connections to the vehicle body. In an amphibious vehicle having at least four wheels, preferably all the road wheels, or all of the driven wheels, are mounted to the vehicle's body with their bearings ahead of the or each lower link connection to the vehicle body.

In a particularly advantageous embodiment, at least one of the lower suspension links is a track control arm.

The arrangement described may be found particularly suitable to a planing vehicle with a mid-mounted transverse engine, due to the hull shape and mechanical layout of such a vehicle. The weight distribution offered by a mid-mounted engine assists planing on water.

The arrangement described also allows a particularly robust mounting for a strut actuator for a retractable suspension, which mounting must withstand retraction and deployment loads as well as normal suspension loading. Should this suspension layout be used in conjunction with the transmission layout of our co-pending application GB0225492.8 (filed herewith), the contents of which are incorporated herein by means of reference, so that the outer CV joint on the or each driveshaft is a plunging joint; the separation of the mountings to the suspension member of the suspension links and of the driveshaft may be advantageous in packaging the bulky plunging CV joint.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is a diagrammatic plan view of an amphibious vehicle according to the invention;

Figure 2 is a perspective view of a rear suspension for the vehicle of Figure 1 as seen from the inside of the vehicle looking outwards, and for clarity not showing the road wheel; and

Figures 3 and 4 are respectively a diagrammatic plan and elevation of a front suspension for the vehicle of Figure 1.

In Figure 1, there is shown an amphibious vehicle 1 having body 3, and a mid-mounted transverse engine 4 arranged to drive through transmission 6 a marine drive means, such as a pump jet 8; and via drive shafts 10, rear road wheels 12. The rear road wheels have suspensions 14, which have suspension links 16; which will be described with reference to Figure 2. The front road wheels 13 have suspensions 15, which have suspension links 17.

Figure 2 shows an upright suspension member 20 having an upward extension 22, and a bearing 24 for supporting one end of drive shaft 10 on the inside; and the wheel on the outside. Member 20 also has connection points for suspension links 16, as will be described below. A disc brake caliper (not shown) is secured to the suspension member at points 26.

Connected between the body of the vehicle and a member 20 are upper links 28 and 30 which connect to extension 22 at 32. Lower links 34 and 36 connect the lower part of member 20 at 38 to the body of the vehicle. It will be noted that the connections between links 34 and 36 and member 20 are behind drive shaft 10. A track control arm 40 also connects between the lower part of member 20 and body 3 (fig. 1).

In order to retract the road wheel into the body of the vehicle, a cylinder 42 is connected to the body by means of trunnions 44. A piston rod 46 acts between cylinder 42 and lower part of member 20 at point 48.

It will be seen that drive shaft 10 and bearing 24 are ahead of any connection of lower links 34 and 36 between the body of the vehicle and the suspension member. This ensures that there is no difficulty in finding room for the engine 4 and suspension connection points to body 3 of the vehicle.

Figures 3 and 4 relate to the front wheels, which are also retractable and which are steerable; these each have a bearing 25 on the outside of suspension member 21. Numeral 27 represents the central axis of bearing 25; which is ahead of any connection of both

lower links 35 and 37, together forming a wishbone between the body 3 of the vehicle and suspension member 21. An upper wishbone having links 29 and 31 connects with an upward extension 23 of suspension member 21 and the body 3. It will be noted that as shown, the front of body 3 is swept up to present a good hydrodynamic profile on water; reducing the amount of chassis space available for lower suspension mountings in front of the centre of rotation of the wheel.

It may also be seen from figure 3 that the rim profile 33 of wheel 13, which is shown in section, is an asymmetric profile, as commonly used in car wheels; and that the upper and lower links support wheel 13 only on that side of the wheel which faces the vehicle.

It will be appreciated by those skilled in the automotive engineering art, that a "connection" between two components may in fact comprise several other components, e.g. a bolt, nut, and washers; which may have a significant length. For clear understanding of the claims, the term "connection" should be understood as the plane in which two adjacent components meet.

It will also be understood that where opposite ends of a suspension link are attached to other components in planes at right angles to each other, it cannot be determined whether one plane is ahead of the other, as the planes intersect. In this case, the mounting positions may be compared by defining a plane at one end of the link as passing through the longitudinal centre line of a connecting element such as a bolt or stud.

It should also be noted that for clarity, figures 3 and 4 do not show components such as the wheel hub and brake which would be needed to complete the wheel mounting arrangement.

An advantage of the present arrangement of the lower wishbone 35/37 being behind the centre of rotation of each front road wheel 13 relates to vehicle dynamics. Vehicle weight ahead of the front wheels is reduced, which may improve steering response. Where the amphibian is designed for off road driving on land – for example to allow it to reach water – it is possible to keep vehicle front overhang to a minimum, so as to reduce grounding by improving the ramp angle. (The front ramp angle being defined, particularly for off road vehicles, as the angle to the horizontal of a line drawn as a tangent to the front wheel to the foremost part of the vehicle) Furthermore, the wheelbase is able to be made as long as possible in proportion to the vehicle's total length. A yet further advantage is that in the case of the vehicle of Figure 1, where the vehicle narrows towards

the front, it is possible to ensure that the lower wishbones can be kept as low as possible to provide a stable support system to each front wheel.

It will be appreciated that further modifications to the suspension layout may also be made as required without departing from the spirit and scope of the invention. In particular, it may be found convenient to apply such a suspension to a vehicle with four or more driven wheels; and to use for example a McPherson strut suspension system, as opposed to the upper wishbone layout described and illustrated. The layout of suspension arms and locations shown is of course applicable to suspensions using a range of spring media, for example coil springs, air or hydraulic springs, or simple or compound torsion bars; with and without further accessories such as anti-roll bars. Various suspension retraction mechanisms may be used to convert the vehicle from road mode to marine mode and vice versa, as are known in the amphibious vehicle art.

The term "body" may be taken to mean an open frame, a monocoque, or any other enclosure.